REDUCED YIELD OF SPRING OAT CULTIVARS BY CEREAL LEAF BEETLES

AGRICULTURAL RESEARCH RESULTS
SCIENCE AND EDUCATION ADMINISTRATION
U.S. DEPARTMENT OF AGRICULTURE

AAR-NC-6
OCTOBER 1980

ABSTRACT

In this research, we determined grain yield loss of oat cultivars commonly grown in cereal leaf beetle infested areas of Michigan. We measured yield loss by comparing grain yield and panicle weights from infested plots with those of uninfested plots at three locations. Two out of three tests showed significant losses in kg/ha grain yield, with an average loss of 17 percent and a range of 4 to 20 percent. The average larval density was one larva per two stems with a range of 0 to 1.2 larvae per stem. Of the yield components, no significant losses were noted in fertile tillers (except in one test where red leaf virus was present), but significant losses were found in kernels per panicle and kernel weight. 'Korwood' and 'Orbit' were the highest yielding cultivars, while 'Clintland 64' was the lowest.

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Published by Agricultural Research, North Central Region
Science and Education Administration
U.S. Department of Agriculture
Peoria, Illinois 61615

ISSN 0193-3825

REDUCED YIELD OF SPRING OAT CULTIVARS BY CEREAL LEAF BEETLES[1,2]

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INTRODUCTION

The cereal leaf beetle (CLB), *Oulema melanopus* (L.), is a pest of the North America oat, *Avena sativa* L., crop. Earlier reports on 'Newton' and 'Jaycee' oat cultivars near New Carlisle, Ind., showed that yield loss ranged from 82 to 147 kg/ha per larva (surviving to pupation), per stem infested (*10*).[5] These reports show also that a CLB larva, in completing development to pupation, consumed 20 percent of the leaf surface of one stem. In cage studies, yields were reduced by 34 and 72 percent from two and four larvae per stem, respectively (*4*). Other tests reported that grain yield was reduced 48.8 percent in 'Putnam' oats grown near Galien, Mich., when the peak CLB population was 10.4 larvae per stem (*6*). Little or no relationship was found between larval feeding damage to foliage and yield of 20 oat cultivars near Columbus, Ohio (*5*). Additional yield loss information is not available for some of the common commercial oat cultivars in beetle-infested areas.

Materials and methods

We conducted yield tests of the following spring oat cultivars in CLB-infested Michigan areas from 1973 to 1976 to determine yield loss caused by this insect over the 4 years. Population densities of the beetle varied between years and location.

Cultivar	C.I. No.	Source	Maturity
AuSable	7670	Michigan	Late
Clintland 64	7639	Indiana	Early
Diana	7921	Indiana	Early
Garry	6662	Canada	Medium to late
Korwood	9167	Michigan	Medium
Lodi	7561	Wisconsin	Medium to late
Mackinaw	9166	Michigan	Late
Mariner	9165	Michigan	Medium-early
Noble	9194	Indiana	Early
Orbit	7811	New York	Medium
Rodney	6661	Canada	Late
Coker 48-70	4867	S. Carolina	Late

'Coker 48-70' was used in place of 'Diana' in 1975. A line from the World Oat Collection, Coker 48-70 had previously shown signs of resistance to larval feeding damage in CLB short-row, plant-resistance nurseries. 'Noble' was tested in 1976 only.

All cultivars were classified as covered oats with spreading panicles. Oats were planted at the rate of 53.8 kg/ha in four-row plots, each 2.4-m long, with 30.5 cm between rows (*1*). Each cultivar was planted twice within a replication. One plot of each cultivar in each replication was allowed to become infested with beetles; the other was insecticide-treated and kept free of beetle larvae (*9*). Each test was a randomized complete block design with four replications (five replications in 1976). The treatment combination was factorial with cultivars as factor A and insecticide-treated vs. untreated plots as factor B. Only 'AuSable', 'Clintland 64', Noble, and C.I. 4867 were tested in 1976. We applied fertilizer with the planter attachment at rates consistent with normal agricultural practices for each location. The soil in Ingham County was classified as Conover (Udollic Ochraqualfs) loam with 0-2 percent slope, while that of the Berrien County site was Riddles (Typic Hapludalfs) loam, with 6-12 percent slope. The soil type at the Shiawassee County test site was Kendallville (Typic Hapludalfs) sandy loam, with 2-6 percent slope. The 1973 plots were sown in Ingham and Shiawassee Counties on April 30. In 1974, the plots were sown in Ingham County on April 30 and in Berrien County on May 1. In 1975, the Ingham County plots were sown on May 8 and in Berrien County on May 7. The 1976 Berrien County plots were sown April 13.

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[1] Coleoptera: Chrysomelidae.

[2] Part of a cooperative project between the U.S. Department of Agriculture, Science and Education Administration-Agricultural Research, and the Entomology and Crop and Soil Sciences departments, Michigan State University, East Lansing. Journal article 8733.

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[5] Italic numbers in parentheses refer to Literature Cited, p. 6.

We made stem counts in 61-cm row sections in each plot as an estimate of panicles per unit area. Plant heights in each plot were recorded, and 30 panicles per plot were collected to determine mean panicle weight. Grain from the two inside rows was harvested and cleaned with a Clipper® seed cleaner, using a No. 20 (round holes) top screen and a No. 9 (triangular holes) bottom screen. We used the cleaned grain weight to estimate kg/ha yield. Three-gram samples of seed from each plot were counted to estimate 1,000-kernel weight. In 1975, the plots were badly lodged by a severe storm, so we used only panicle samples as a yield index; kernel weight was determined from seed of the threshed panicles.

Estimates of leaf feeding damage were made in the 1975 Berrien County test. We removed the flag leaves and the first two leaves below the flag leaf from four stems randomly chosen in insecticide-treated and untreated plots of five cultivars on July 2. The leaf samples were taped to white paper with transparent mending tape so the visual estimates of feeding damage could be made later.

In 1974, 30 stems chosen at random from each untreated plot of four selected cultivars were examined for CLB larvae at weekly intervals from the time larvae were found until shortly before pupation, while larval counts were made in plots of all the untreated entries in 1975 and 1976. Estimates of peak larval density were obtained from these counts; cumulative egg counts were made in 1973 and 1975 for all entries (3).

Results

Table 1 shows yield parameters of the untreated plots, including percent loss from corresponding treated plots for kg/ha, panicle weight, and plant height, an index of straw loss.

Highly significant losses in kg/ha occurred in the 1973 Shiawassee County plots (27.2 percent) and in Ingham and Berrien Counties in 1974 (17.7 and 19.5 percent, respectively). Lodging prevented harvesting the plots for kg/ha measurements in 1975.

Figure 1 shows the grain yield (kg/ha) of insecticide-treated cultivars plotted against the yield of the untreated cultivars. A significant correlation ($r = 0.863$) existed between yields of treated and untreated cultivars indicating that, on the whole, all cultivar responses to beetle attack were similar. However, yield points of 'Orbit' and 'Mariner' were considerably above the regression line. 'Korwood' was the highest yielding cultivar in the test, while Clintland 64 was the lowest.

In the absence of kg/ha grain yield loss data, panicle weights can serve as a partial loss index. We detected highly significant reductions (12-13 percent) in panicle weights in the 1973 Shiawassee County and 1975 Berrien County tests, with significant reductions measured in the 1974 Berrien County test (table 1). There were slight but significant reductions in plant height in three of the tests, with a range of 0-4.9 percent loss in all seven tests (table 1).

TABLE 1.—Cereal leaf beetle larval infestation and yield measurements of kg/ha, panicle weight, and plant height of CLB infested oat plots with no insecticide treatment

Michigan counties	Larvae/stem ± S.E.[1]	Percent tillers with larvae ± S.E.[1]	kg/ha: kg	kg/ha: Percent loss[2]	kg/ha: Sign. level[3]	Panicle weight: Grams	Panicle weight: Percent loss[2]	Panicle weight: Sign. level	Plant height: cm	Plant height: Percent loss[2]	Plant height: Sign. level
1973:											
Ingham	ND[4]	ND	1496	3.9	ns	0.85	1.2	ns	92.5	No loss	
Shiawassee .	ND	ND	887	27.2	**	0.72	13.3	**	86.0	1.5	ns
1974:											
Ingham	0.40 ± 0.10	26.9 ± 7.3	2225	17.7	**	1.17	No loss		84.1	2.8	*
Berrien	1.00 ± 0.20	50.2 ± 5.7	1870	19.5	**	0.94	12.1	*	84.9	3.3	*
1975:											
Ingham	0	0	ND lodged			1.20	No loss		92.5	No loss	
Berrien	1.20 ± 0.20	69.5 ± 2.4	ND lodged			1.22	12.2	**	100.8	4.9	**
1976:											
Berrien	0.06 ± 0.08	4.7 ± 2.5	913	3.6	ns	ND			54.6	3.9	ns

[1] n = 16, 1974; 40, 1975; 20, 1976.
[2] = yield data of insecticide-treated plots, with no CLB, used as a base.
[3] ns = not significantly different at the 0.05 probability level.
* = significantly different at the 0.05 probability level.
** = significantly different at the 0.01 probability level.
[4] ND = no data.

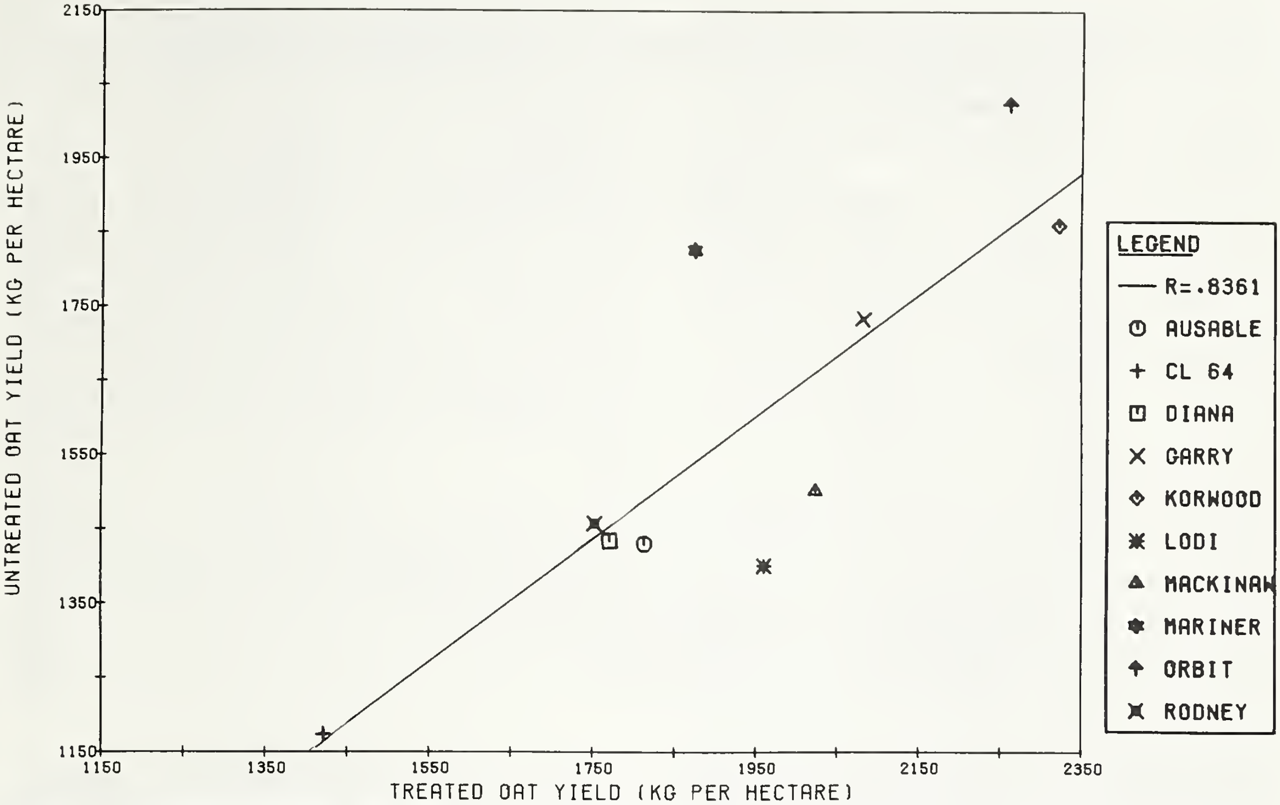

FIGURE 1.—Relationship of kg/ha grain yield of insecticide treated oat plots and cereal leaf beetle infested (untreated) plots. $Y = 12.5 + 0.83x$.

Yield in small grains has been divided inta three components: (1) number of fertile tillers per length of row (**X**); (2) number af kernels per panicle (**Y**); and (3) kernel weight (**Z**) (2). Table 2 shaws the effects af CLB damage on these campanents.

We found a slight reductian in the number of fertile tillers (**X**), with highly significant losses occurring only in the 1973 Shiawassee Caunty test. Kernels per panicle (**Y**) were significantly reduced in the 1974 and 1975 Berrien Caunty tests, but there were no significant differences between other treated and untreated plots where this parameter was measured. Kernel weights (**Z**) from beetle-infested plots were significantly lawer (almost 3 percent)) than those from treated plats anly in 1974.

Egg laying spring adults caused some feeding damage to seedlings of the untreated plots in May. A lesser degree af spring adult feeding damage was nated in the insecticide-treated plats, and dead adults were readily observed an the ground between rows of these plots. CLB larval feeding damage in late June and early July to the flag leaf and to the first and second leaves below the flag leaf of selected entries from bath treated and untreated plats is reparted in table 3. Some of the damage, especially to the insecticide-treated plots, also was caused by newly emerged summer adults which, unlike the larvae, usually do not damage oats extensively. We faund much less larval feeding damage in our plots at the flag leaf stage of growth than is shown in previous reports where more than 90 percent leaf-feeding damage was faund in some plots (*6, 10*).

CLB populatian estimates as measured by larvae per stem are shown in table 1 for 1974 to 1976. The populatian density was lawest in the 1975 Ingham Caunty plats (0 larvae/stem) and greatest in the 1975 Berrien County plats (1.2 larvae/stem). There were no statistical differences in CLB larval or egg density between cultivars within each year. Figure 2 shaws larval density and grain yield of 12 individual plots from three cultivars with similar yield ranges for the 1974 Berrien County test. The linear correlation ($r = 0.5069$) was significant at the 0.05 level af probability.

There were no counts of larvae per stem for 1973, but cumulative egg counts were campared with similar counts in the 1975 Berrien County test (table 4). The egg density in 1975 was much greater than that of either 1973 lacation; however, the kg/ha yield loss

TABLE 2.—Cereal leaf beetle damage on oat yield components; number of fertile tillers per 61 cm (X); number of kernels per panicle (Y); and 1000 kernel weight (Z)

	X Tillers			Y Kernels per panicle			Z 1000 kernel weight		
Year and location	No. per 61 cm.	Percent loss[1]	Sign. level[2]	No. of kernels	Percent loss[1]	Sign. level	Grams	Percent loss[1]	Sign. level
1973:									
Ingham	77.1	1.40	ns	31.7	No loss		23.0	2.87	ns
Shiawassee	57.6	16.80	**	ND[3]			ND		
1974:									
Ingham	60.9	3.02	ns	47.0	No loss		24.9	2.92	*
Berrien	64.9	1.21	ns	36.4	9.22	*	25.9	2.74	*
1975:									
Ingham	ND			ND			22.9	No loss	
Berrien	45.3	0.22	ns	47.5	13.80	*	25.8	No loss	
1976:									
Berrien	52.7	3.65	ns	ND			ND		

[1] Yield data of insecticide-treated plots with no cereal leaf beetles as a base.
[2] ns = not significantly different at the 0.05 probability level.
* = significantly different at the 0.05 probability level.
** = significantly different at the 0.01 probability level.
[3] ND = no data.

(percentage basis) was disproportionately greater in the 1973 Shiawassee County test, probably because of a severe red leaf (barley yellow dwarf) epidemic. Red leaf is transmitted by grain aphids, and the insecticide treatment may have reduced the aphid population as well as the CLB population. Red leaf ratings based on a 0-5 visual scale (0 = 0 percent red leaf, 5 = 100 percent red leaf) were made at both 1973 locations

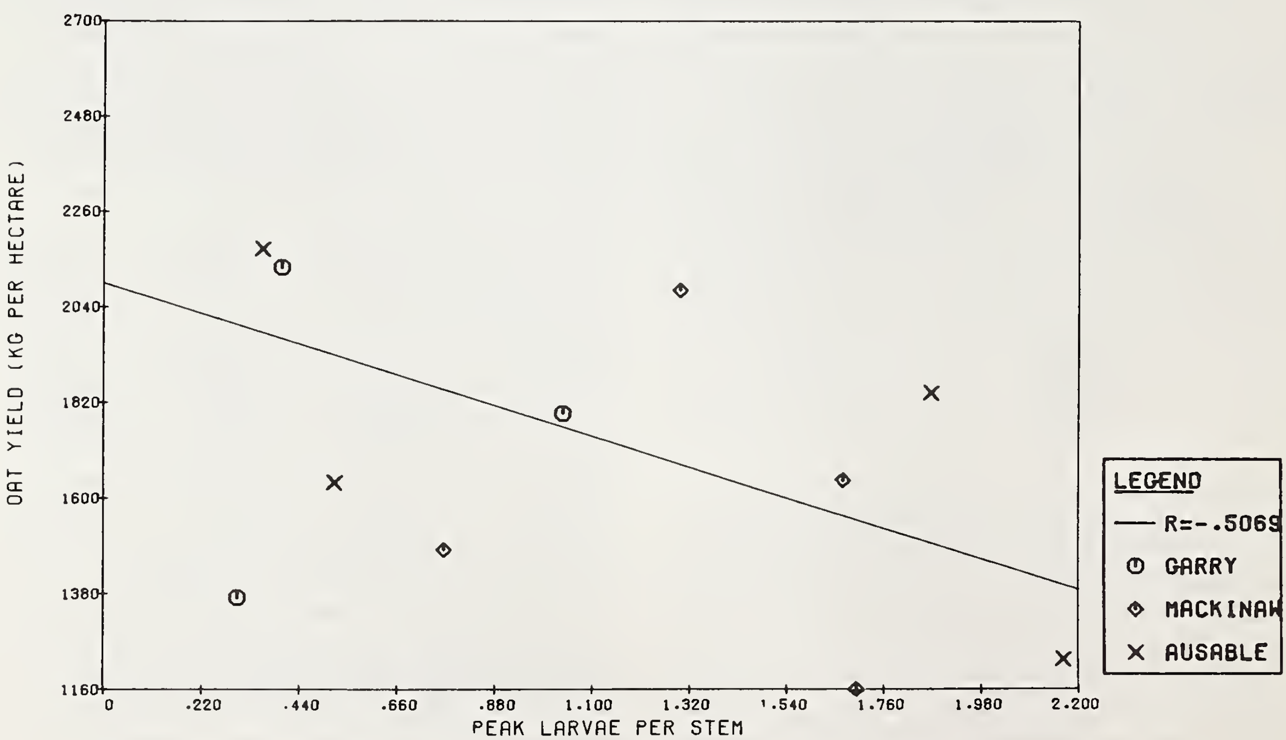

FIGURE 2.—Relationship of peak cereal leaf beetle larvae per stem and kg/ha oat yield. Y = 2094 — 320.8x.

TABLE 3.—Leaf damage of oat cultivars by cereal leaf beetles,[1] Berrien County, Mich.

Leaf	Percent CLB feeding damage		Percent leaves with CLB feeding damage	
	Infested plots	Control plots	Infested plots	Control plots
Flag leaf	5.9	0.8	35.0	26.7
First leaf below flag leaf ..	13.6	6.6	86.7	73.3
Second leaf below flag leaf	11.5	5.4	89.8	79.3

[1] Leaves cut July 2, 1975, from four stems in infested and control plots of each of five cultivars. Mean of 60 leaves of each type evaluated, except that means of 49 and 58 second leaves below the flag leaf were obtained from infested and control plots, respectively.

and are shown in table 5. Red leaf was greater in the untreated plots and was also greater in the Shiawassee County plots than in Ingham County plots. For this reason, the yield losses at the 1973 Shiawassee County location can be only partially attributed to CLB damage.

Discussion

Figure 1 shows that Orbit and Korwood are good cultivars in the CLB locations tested, based mainly on their intrinsic higher-yielding ability. Good resistance to CLB is not available in commercially grown oat cultivars, although those cultivars that are considerably above the regression line in figure 1 (Orbit, Mariner) merit further investigation. CLB resistance in the form of antibiosis caused by leaf pubescence in an *Avena sterilis* line has been reported (*8*), but there is no appreciable leaf pubescence in commercial oat cultivars. Coker 48-70 showed some resistance to larval feeding damage in short-row field nurseries, but it did not have exceptional resistance in the 1975 yield test, which emphasizes the importance of using more than one type of test in isolating and developing CLB resistance in oats.

TABLE 4.—Cumulative cereal leaf beetle egg counts in untreated oat plots

Michigan counties	Eggs per 61 cm of row ± S.E.[1]	Date of last count
1973:		
Ingham	90.1 ± 2.3	June 19
Shiawassee	20.1 ± 2.2	June 20
1975:		
Berrien	276.0 ± 12.7	June 3

[1] n = 10. Data from 1973 samples (30.5 cm of row) multiplied by 2 to facilitate comparison with 1975 data.

TABLE 5.—Red leaf disease rating on a 1-5 scale of insecticide treated and untreated oat plots. 1 = 0-20 percent red leaf; 5 = >80 percent red leaf

Michigan counties	Insecticide treated ± S.E.[1]		Untreated ± S.E.
1973:			
Shiawassee	3.67 ± 0.03	*[2]	4.25 ± 0.12
Ingham	3.28 ± 0.02	ns	3.50 ± 0.17

[1] n = 40.
[2] * = horizontal means significantly different at the 0.05 probability level.
ns = not significantly different.

We obtained information on the effect of CLB on the three components of yield: fertile tillers per unit area (**X**); kernels per panicle (**Y**); and kernel weight (**Z**). There were losses in kernels per panicle and kernel weight but only a slight reduction in fertile tillers per unit area, except for a 16.8 percent reduction in tillers in the 1973 Shiawassee County test. But this reduction was undoubtedly caused by red leaf virus. It seems that CLB could have an important impact on tiller production, especially when beetles are abundant during the early seedling crop stage. The effect of CLB on this yield component has not been reported, although some research shows losses in kernels per panicle and kernel weight. CLB effect on yield components is intertwined with available soil moisture and nutrients, heat units, and the presence or absence of plant diseases. Thus, the same peak larval density will not always have the same effect on individual components at different locations in different years.

In 1975, leaf-feeding damage estimates were made from samples collected on July 2. Summer adults had just begun to emerge from the pupal cell, so we attributed some of the damage to the untreated plots, and most of the damage to the insecticide-treated plots, to summer adult feeding. These damage estimates were low and led us to conclude that the major damage to the plants occurred earlier in their development in this test. The upper leaves play an important role in forming grain; thus, direct feeding on these leaves can affect yield. In addition, earlier growth-stage stresses affect the size and condition of the flag leaf and associated leaves, which will, in turn, affect grain yield. None of the reports, including ours, has quantified CLB damage to oats at earlier stages of growth in relation to grain yield reduction.

Plotting larval density against grain yields of individual cultivar plots in similar yield ranges did not show the close linear relationship as that in other re-

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ports, where a linear relationship of 0.85 and 0.73 was found between larval density and grain yield in 1966 and 1968, respectively (*10*). However, there was a much greater range of larval density in those tests obtained by different concentrations of insecticide. Also, the peak larval densities were much greater. We conducted our studies when CLB populations were lower, and they probably reflect infestation levels and yield losses of oats by this insect over the long term in infested fields. We do not clearly understand, however, in a given year, why some oat fields in a beetle-infested area do not become infested, while others may be more infested and damaged than we have reported.

ACKNOWLEDGMENTS

We thank Lynn Bassler, S. J. Jennings, D. K. Ries, D. E. Wolfe and the USDA, Niles, Mich., APHIS lab employees for technical assistance in this study.

LITERATURE CITED

(*1*) Cobb, D. L., B. L. Doyle, J. A. Webster, D. H. Smith, Jr., and D. K. Ries. 1977. Rear-mounted planter for small grain yield trials. Agronomy Journal 69:896-989.

(*2*) Grafius, J. E. 1956. Components of yield in oats: a geometrical interpretation. Agronomy Journal 48: 419-423.

(*3*) Helgesen, R. G., and D. L. Haynes. 1972. Population dynamics of the cereal leaf beetle, *Oulema melanopus* (L.): a model for age specific mortality. Canadian Entomologist 104:797-814.

(*4*) Koval, C. F. 1966. The cereal leaf beetle in relation to oat culture. Ph.D. Thesis. University of Wisconsin. 120 p.

(*5*) Lyon, W. F., and D. A. Ray. 1969. Cereal leaf beetle infestation on 20 varieties of drill-seeded spring oats in Franklin County, Columbus, Ohio, 1968. Proceedings of the North Central Branch of the Entomological Society of America 24:21-2.

(*6*) Merritt, D. L., and J. W. Apple. 1969. Yield reduction of oats caused by the cereal leaf beetle. Journal of Economic Entomology 62:298-301.

(*7*) Painter, R. H. 1951. Insect resistance in crop plants. 520 p., Macmillan, New York.

(*8*) Steidl, R. P. 1979. Cereal leaf beetle plant resistance: antibiosis in an *Avena sterilis* introduction. Environmental Entomology 8:448-450.

(*9*) Webster, J. A., D. H. Smith, Jr., and C. Lee. 1972. Reduction in yield of spring wheat caused by cereal leaf beetles. Journal of Economic Entomology 65:832-835.

(*10*) Wilson, M. C., R. E. Treece, R. E. Shade, K. M. Day, and R. K. Stivers. 1969. Impact of cereal leaf beetle larvae on yields of oats. Journal of Economic Entomology 62:699-702.

U.S. GOVERNMENT PRINTING OFFICE 827-023